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# Unmanned Aerial Vehicles and hydraulics

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Unmanned Aerial Vehicles (UAVs) can provide accurate hydraulic observations with high spatial resolution and timely delivery. UAV-borne observations are a new dataset in hydrology that will be essential in areas not covered by the existing in-situ gauging network, especially for monitoring of remote and hard-to-access inland water bodies. UAV can obtain observations of: i) water surface elevation (WSE), ii) water depth and bathymetry, and iii) surface water speed of inland water bodies.

WSE can be measured from UAVs with a radar system and a GNSS (Global Navigation Satellite System) receiver, without need for Ground Control Points (GCPs) [1]. The GNSS receiver measures the altitude above mean sea level, while the radar measures the range to the water surface. The WSE is then computed subtracting the range measured by the radar from the GNSS-derived altitude. Compared to satellites, UAVs have several advantages: high accuracy and spatial resolution, mission repeatability, flexible flight routes, and accuracy better than 7-10 cm.

Water depths (and bathymetry) can be measured with a tethered sonar dragged by the UAV. We achieved an accuracy of ca. 2.1% of the actual depth with this system, with a maximum depth capability potentially up to 80 m [2]. Since other remote sensing techniques (e.g. LIDARs, through-water photogrammetry, spectral-depth signature of multispectral imagery) can survey water depths only up to a few decimeters (maximum 1-1.5 m), our technology has a maximum depth capability and an applicability range superior to other remote sensing techniques.

Surface water speed can be measured from UAVs using LSPIV (Large Scale Particle Image Velocimetry) [3] [4] [5] [6]. New LSPIV methods [7] [8] have been developed to estimate water flow by focusing only on natural tracers, such as foam, ripples generated by turbulence and differences in water color created by sediments or suspended solids. These new methods overcome the requirement for artificially seeding the water surface.

Combining UAV-borne water depth and surface velocity observations will enable the estimation of river discharge. UAV-borne hydraulic observations of discharge and WSE, retrieved in different hydrological conditions and at different time points, can be used to construct rating curves and, in combination with satellite radar altimetry data, can complement in-situ river gauging stations.

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